Keeping Our Firefighters Safe from Toxins and Carcinogens

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CERTIFICATION STATEMENT

I hereby certify that this paper constitutes my own product, that where the language of others is set forth, quotation marks so indicate, and that appropriate credit is given where I have used the language, ideas, expressions, or writings of another.

Signed: _____

Abstract

This research paper focuses on the risk of known toxic substances and carcinogens associated with firefighting. Despite the evidence firefighters continue to expose themselves to these toxins. Firefighters are not sufficiently trained to be aware of known toxic substances and carcinogens lacks.

The problem is that despite the evidence of research the Carson City Fire Department has not developed an action plan and policy to prevent and mitigate these hazards. The Purpose of this research is to evaluate the need for development of an action plan and policy to prevent and mitigate exposure to known toxins and carcinogens.

This is a evaluative research project addresses the following questions: What toxic substances and carcinogens are present during firefighting? Is there a correlation between specific types of cancer? What are the common safe practices in the fire service that prevent or reduce fire scene exposure?

The results of the research revealed an abundance of toxins and carcinogens present at fires. The research showed that toxic substances are present and what is highly probable in causing cancer to today's firefighter. Additionally, further studies must be conducted for a definitive answer as to correlation of the profession and cancer. Researchers appear to lack a consistent way of tracking firefighters.

One reason for the elaborate length of this study time is due to the latency of certain types of cancer. In one study on exposure response relationships, "a standardized mortality ratio for multiple-myeloma demonstrated an increasing trend with duration of employment as a firefighter" (Lemasters, Genaidy, Deddens, Sobeih, Barriera-Viuret,

Dunning, and Lockey, 2006). Researchers found that firefighters employed for more than 20 years had a higher of dying from cancer (2006).

The recommendations from this research suggest that the presence of toxic substances is prevalent. Furthermore, that these toxic substances and carcinogens have a direct correlation to being cancer causing to firefighters. The fire service establishes little in safe practices to reduce fire scene exposure. Based on the research the author concluded that an action plan and policy to prevent, mitigate and reduce the firefighter exposure to the presence of cancer causing toxins should be done through policy, education, constant reinforcement and accountability of it's officers and firefighters.

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Introduction

Today's firefighters are the better equipped, educated and as brave today as the day they put on the badge to serve. Unfortunately, we as fire service leaders have failed to educate them properly. We have taught them basic and advanced firefighting skills, EMS education to care for the sick and injured, hazardous materials skills, and body substance isolation skills to deal with potentially contaminated body fluids.

What we have failed to educate and train them in is to how not to become exposed to toxic substances and known carcinogens, so that they do not suffer career ending injury or worse, die prematurely. As fire service leaders, we have trained firefighters to properly wear personal protective clothing (PPE) including their self-contained breathing apparatus (SCBA). However, we have only trained them to wear the SCBA in the presence of smoke and fire. Unfortunately, we don't train them to recognize the real danger of carcinogens found in the atmosphere.

"The media blitz surrounding firefighter death, injury and disability has certainly heightened our awareness of the acute causes of firefighter morbidity and mortality. Virtually unspoken about, however, are deaths and career-ending conditions caused by chronic diseases, like cancer" (Kistner, 2007, p. 136). We must do better than merely being aware of the threat of cancer to our firefighters. We must take action. This research addresses the action needed to prevent and mitigate the threat of cancer to firefighters.

This researcher currently serves as an operations battalion chief for the Carson City Fire Department (CCFD). One of the functions of the position is to serve as an incident commander, division group supervisor, and incident safety officer. Over the past

several years while functioning in these positions, this researcher has grown very concerned with the lack of PPE or awareness of the need to wear the SCBA in and around fire and the products of combustion. Our department has policy enforcing the use of PPE and SCBA. However, it is only enforced by tactical supervisors and firefighters in obvious fire conditions and immediately dangerous to life and health (IDLH) environments. PPE is worn primarily during the initial phases of fire, yet rarely during salvage and overhaul. When the likely hood of incomplete combustion and toxic substances may be the highest.

While managing the oversight for selection, care, and maintenance of PPE this researcher became acutely aware of the lack of PPE cleanliness. This has led this researcher to begin researching the correlation of the presence of toxic substances and carcinogens, in an effort to educate line personnel on the effects of improperly cleaned PPE and exposure. What was discovered through an impromptu literature review, primarily via the Internet, is a lack of awareness and research on the subject. This has led this researcher to further continue this research formally as a required research project through the Executive Fire Officer Program.

The problem is that firefighters are exposed to known toxic substances, many of which are known carcinogens during firefighting. Despite this recent evidence the Carson City Fire Department has not developed an action plan and policy to prevent and mitigate these hazards.

The purpose of this research is to evaluate the need to develop an action plan and policy that encompasses prevention and mitigation of the known toxic substances and carcinogens to firefighters. While we cannot reduce the cause or amount of these toxic

substances and carcinogens, we can and should work toward preventing unnecessary exposure and mitigate the fire scene where we can and when we can toward this effort. This is an evaluative research project undertaken to address the following questions:

1. What toxic substances and carcinogens are present during firefighting?
2. Is there a correlation between specific type of cancer and the occupation of a firefighter?
3. What are the common safe practices in the fire service that prevent or reduce fire scene exposure?

Background and Significance

The Carson City Fire Department is an incorporated municipality that serves a population of 57,000 within 146 square miles. The department consisting of 65 personnel operates from three stations and provides the following services: fire suppression, wildland firefighting, advanced life support emergency medical services and transport, hazardous materials response, technical rescue, fire prevention and code enforcement.

In 2009 the Carson City Fire Department had its first LODD directly related to cancer. An active duty chief officer was suddenly diagnosed with a brain tumor known as Glioblastoma, which is a aggressive form brain cancer, and died six weeks after diagnoses. This is the first ever cancer related death in the department's history. This same chief officer was in his 35th year of service and recently fought and won a battle with prostate cancer a year earlier. Two years earlier a retired battalion chief was diagnosed with Chronic Lymphocytic Leukemia cancer. This retired chief officer was also a 30 year veteran of the fire service. Prior to 2007 there is no record of any other member being diagnosed with any form of cancer.

These recent diagnoses of cancer, recent journal articles such as retired Chief Mario Trevino's "We Danced With the Devil: One Firefighter's Cancer Chronicles" (Trevino, 2009) made this researcher more keenly aware of the need to research the potential correlation of the presence of known carcinogens and the fire fighting profession. The Carson City Fire Department has taken specific measures to reduce exposure to known or suspected carcinogens. Each station is equipped with an active exhaust system, and all members all trained in the use of PPE, SCBA and the care and maintenance of their PPE. However, what we cannot change is the culture for which we live and operate.

Today's structural fires are producing byproducts of petrochemicals and aromatic hydrocarbons which are particularly dangerous to firefighters. This danger of firefighting is likely to become worse. This is a primary reason that the Carson City Fire Department as an organization must do everything it can to prevent, mitigate and reduce these known carcinogenic hazards to firefighters.

Researchers in past decades have proven a relationship between firefighting and cancer. The American Journal of Industrial Medicine published a study on the evidence of cancer among male firefighters in Massachusetts.

> In their introduction of this study, (Kang, Davis, Hunt, and Kriebel 2007) succinctly make this statement in support of this relationship. Firefighters are known to be exposed to recognized or probable carcinogens. These include benzene, polycyclic aromatic hydrocarbons, benzo (a) pyrene, formaldehyde, chlorophenols, dioxins, ethylene oxide, orthotoluidine, polychlorinated biphenyls,

vinyl chloride, methlyene chloride, trichloroethylene, diesel fumes, arsenic and asbestos (Kang et al. 2007).

The National Fire Academy's Executive Fire Officer Program promotes proactive leadership and the need to transform fire and emergency services (National Fire Academy, 2009, p. I-4). This research directly relates to the United States Fire Administration operational objectives to "improve the fire and emergency services' capability for response to and recovery from all hazards" (NFA 2009, p. II-2). Recovery from all hazards includes the safety and health of firefighters. This project of research on the known toxic substances and carcinogens and the correlation to firefighters will enable the Carson City Fire Department to establish a policy that encompasses the prevention and mitigation of these hazards.

Literature Review

A review of existing literature on toxic substances and known carcinogens established a foundation for this research. The first step in this literature review was to determine what toxic substances and carcinogens are commonly present during firefighting. Much of the literature focused on contributing factors to specific types of cancer, like prostate cancer. What is most common in this literature review was the presence of numerous known carcinogens and toxins which contribute to the increasing toxic environment of the firefighter. One of these factors is the presence of organic compounds.

In their 2001 article, "Characterization of volatile organic compounds In smoke at municipal structure fires," (Austin, Wang, Ecobichon and Dussault, 2001) describe a connection between volatile organic compounds in smoke and adverse

> health effects on firefighters. Gas chromatography/mass spectral detection was used to analyze more than 144 compounds. Among the carcinogens recognized, researchers identified a preponderance of benzene, styrene, and toluene. These compounds are prevalent at every fire, though in varying amounts and in combination with other familiar compounds, such as hydrogen cyanide and carbon monoxide.

Air contaminants encountered by firefighters were substantiated in the City of Boston in 1980. Researchers suspected air contaminants causing acute and chronic health problems for firefighters. Two hundred fires were sampled using personal air samplers to measure concentrations of these contaminants. While their study was aimed at the treatment of smoke inhalation victims, it provided data that supported the need to wear SCBA to reduce exposure to these noted air contaminants that result in structure fires; further establishing the presence of known toxins substances and carcinogens. This study focused on carbon monoxide (CO), oxygen (O2), hydrogen chloride (HCL), hydrogen cyanide (HCN), nitrogen dioxide (NO2), carbon dioxide (CO2) and particulates. Carbon monoxide was an acute hazard, hydrogen cyanide occurred in low concentrations as was hydrogen chloride. Carbon dioxide, nitrogen dioxide, and oxygen depression were not significant hazards. This provides insight into the origin of diseases that affect the firefighter population. (Treightman, Burgess, and Gold 1980).

Studies suggest that aldehydes may play an important role in respiratory injury to fire victims and implicate acrolein specifically as a contaminant. Benzene was identified among numerous aromatic hydrocarbons in preliminary samples of the Boston research. These sources of benzene in fires include petroleum products and the thermal degradation

of certain plastics. Particulates are present in high concentrations and may provide absorption sites for irritating gasses and vapors with subsequent transport to the non-ciliated portion of the broncheo-tracheal system (Treightman et al. 1980).

"Firefighting involves sporadic exposures to high concentrations of contaminants for brief periods under circumstances of severe physical stress" (Treightman, 1980, p. 797). This research clearly establishes a need for firefighters to protect themselves by using their SCBA; It also provides substantial proof to the existence of carcinogens in the firefighter's environment. The threat of exposure to carcinogens in smoke is realized by a firefighter only when the presence of smoke and vapors exists. However, the toxic substances still exist even when the firefighter cannot see it.

The National Research Council's committee on Fire Toxicology bests explains the present day issue of exposure to carcinogens in fire smoke.

> A complex mixture of toxic gases, fumes, and particulates is produced when buildings and their contents burn. Although the combustion of traditional building materials may produce toxic substances, firefighters probably are exposed to a greater variety now than in past due to the increasing introduction of plastics and other synthetic compounds into building materials and furnishings. The most commonly observed carcinogens in fire smoke are benzene and polycyclic aromatic hydrocarbons, such as benzo[a]pyrene (Sama, Martin, Davis, and Kriebel 1990).

Environmental carcinogens continue to expose firefighters on fires. In a 1940's study based in Toronto, a 25 year study of firefighter deaths in active firefighters found a steady increase in cancer from 15.4% in 1945-49 to 38.4% in 1965-70. It was believed that this

increase was due to synthetic organic chemicals (Edado, Olcemendy, and Riquel, 1978). Specifically noted in this research was the 'presence of chlorinated hydrocarbons, which can be found in most any plastic found in a structure, including the plastic insulation of wiring. The unpolymerized vinyl chloride monomer gives off varying amounts of the carcinogenic vinyl chloride" (Edado et al. 1978).

Possible carcinogens of colon cancer are asbestos and polycyclic aromatic hydrocarbons (PAHs) (Siemiatyck, Richardson, Straif, Latreille, Kakhani, Campbell, Rousseau, and Boffetta 2004). "These are known to be found in the work environment of firefighters" (Markowitz, Garibaldi, Lilis and Landrigan 1992). "Brain carcinogens, which firefighters may be exposed to include vinyl chloride, benzene, n-hexane, PAHs, Polychlorinated biphenyls (PCBs), N-nitroso compounds, lead, arsenic, and mercury" (Beall, Delzell, Rodu, Sthiakumar, Lees, Breysse, and Meyers 2001).

The next step in literature review was to see if there is there a correlation between specific types of cancer and the occupation of a firefighter? Researchers have established direct correlation and relationship of toxic substances that are known to be carcinogens. Several studies on the relationship between firefighters and cancer suggest that "leukemia, non-Hodgkin's lymphoma, multiple myeloma, brain and bladder cancer have strong evidence, and rectal, colon, stomach, prostate cancer, and melanoma have a weaker but plausible evidence of association with firefighting (Kang et al. 2007).

As cited earlier, a Boston Massachusetts-based study of cancer incidents to firefighters and air contaminants, focused on incidents of cancer among male firefighters from 1987-2003. The research was gathered from a cancer registry in Massachusetts

among males beginning at the age of 17. Among the 258,964 registered 2,125 were identified as firefighters (Trieghtman et al. 1980)

Reviews of the study identified strong evidence between firefighting and a number of aforementioned cancers. A lesser relationship but plausible evidence of cancer of the rectum, colon, stomach, prostate, and melanoma also exists (Golden et al. 1995). The strongest association between cancer and firefighting appears to be in cancer of the colon and the brain. One of the documented causes of colon cancer are asbestos and polycyclic aromatic hydrocarbons (Siemiatycki et al. 2004). These are known to be found in the work environment of firefighters (Markowictz et al. 1992). Brain carcinogens that firefighters may be exposed to include vinyl chloride, benzene, n-hexane, PAHs, Polychlorinated biphenyls (PCBs), N-nitroso compounds, lead, arsenic, and mercury (Beall et al. 2001).

Most meta-analysis' or case control studies [emphasis added] provided little qualitative evidence to the correlation between specific types of cancer and the occupation of a firefighter. In reviewing almost a dozen studies most of these had small sample or cohort groups used for their analysis. The largest study was a Meta-analysis of 32 different studies on cancer. The meta-analysis had virtually no differing opinion then the smaller studies, when it came to correlation. Virtually all studies list 'probable' or 'possible' due to no overwhelming statistical difference. One doctor has an opinion of how researchers can come to a consensus on cancer risk to firefighters.

> Dr. Bates, Phd suggests that to prove a final resolution of the question of whether firefighters are at increased occupational cancer risk will probably require a large occupational cohort study followed by a nested case-control study (probably

> with several cancer endpoints) that combine record and questionnaires to collect detailed covariate data. However, reconstruction of firefighting exposure histories will be challenging. Most of the approximately 25 other published investigations of cancer in firefighters have been cohort studies and relatively small. To date, none of these cohort studies has been followed by a nested case-control study (Bates, 2007).

Aside from the presumptive nature of the firefighter occupation, and the products that are being burned in a fire; there is suitable causal factors to support that firefighters are at risk. This is exemplified in my home state of Nevada by the State Legislature. The Nevada Legislature recognized the presumptive nature of cancer and the firefighters occupation by providing an insurance law that protects, compensates and recognizes cancer as an occupational disease. NRS Section 617 Occupational Diseases, NRS 617.453 Cancer as occupational disease of firefighters, section 1 states

"Notwithstanding any other provision of this chapter, cancer, resulting in either temporary or permanent disability, or death, is an occupational disease and compensable as such under the provisions of this chapter" (NRS, 2009, 617.453 (1) part (a). The legislative body recognized the overwhelming evidence of known cancer causing substances and furthermore, listed a comprehensive list of known carcinogens that if a firefighter contracts are presumptive and therefore compensable. These include but are not limited to:

> (a) Diesel exhaust, formaldehyde and polycyclic aromatic hydrocarbon shall be deemed to be known carcinogens that are reasonably associated with bladder cancer.

(b) Acrylonitrile, formaldehyde and vinyl chloride shall be deemed to be known carcinogens that are reasonably associated with brain cancer.

(c) Diesel exhaust and formaldehyde shall be deemed to be known carcinogens that are reasonably associated with colon cancer.

(d) Formaldehyde shall be deemed to be a known carcinogen that is reasonably associated with Hodgkin's lymphoma.

(e) Formaldehyde and polycyclic aromatic hydrocarbon shall be deemed to be known carcinogens that are reasonably associated with kidney cancer.

(f) Chloroform, soot and vinyl chloride shall be deemed to be known carcinogens that are reasonably associated with liver cancer.

(g) Acrylonitrile, benzene, formaldehyde, polycyclic aromatic hydrocarbon, soot and vinyl chloride shall be deemed to be known carcinogens that are reasonably associated with lymphatic or haemotopoietic cancer.

(h) Diesel exhaust, soot, aldehydes and polycyclic aromatic hydrocarbon shall be deemed to be known carcinogens that are reasonably associated with basal cell carcinoma, squamous cell carcinoma and malignant melanoma.

(i) Acrylonitrile, benzene and formaldehyde shall be deemed to be known carcinogens that are reasonably associated with prostate cancer.

(j) Diesel exhaust, soot and polychlorinated biphenyls shall be deemed to be known carcinogens that are reasonably associated with testicular cancer.

(k) Diesel exhaust, benzene and X-ray radiation shall be deemed to be known carcinogens that are reasonably associated with thyroid cancer. (NRS, 2009)

The NRS further delineates the length of coverage by stating that the employee must have at least five years of service and is covered after retirement. Retirement coverage is up to a minimum of 60 months and up to a period calculated by multiplying 3 months times the number of full years of service NRS (2009). Nevada is only one of 24 states with such presumptive cancer legislation. According to the National League of Cities report on Assessing State Firefighter Cancer Presumption Laws and Current Firefighter Cancer Research:

> Forty-three states have enacted laws that allow firefighters and emergency medical services (EMS) providers who develop certain injuries, illnesses, and diseases to qualify for workers' compensation and certain other benefits under a presumption that the injuries, illnesses, and diseases are work-related. Cancer is one of the diseases covered in 24 state presumption laws. Eight other states have pending cancer presumption legislation. (TriData, April 2009).

This leaves many states with no such legislation to protect its firefighters, despite the evidence of known carcinogens. The literature review revealed a preponderance of research that while comprehensive, fails to draw conclusive evidence to support an overwhelming and specific correlation of certain cancers and the occupation of a firefighter. This researcher is only suggesting that of all of the research that has been found, few have truly reached into the cause and correlation, let alone to come up with a method to truly capture this data from firefighters and retirees. One research team discusses another difficulty in a narrowing down what firefighters are exposed to.

> What also makes the correlation difficult is the proliferation of plastic products in the last two decades has resulted in a qualitative change in the nature of the

> compounds to which firefighters are exposed at fires. Firefighters will continue to be exposed to these substances while the toxicological information needed to judge the consequences of their exposure is slowly amassed (Hilado et al. 1978).

The next step in the literature review was to research what are the common safe practices in the fire service that prevent or reduce fire scene exposure. For the purpose of this research, the standards for the fire service established in the The National Fire Protection Association (NFPA) were utilized. NFPA is currently the only nationally recognized firefighting set of recommended standards created specifically for firefighters.

In addition to NFPA standards, this researcher utilized the CCFD manual on firefighting called Fundamentals of Fire Fighter Skills (Jones and Bartlett Publishers 2004). This is the current manual utilized by CCFD and forms the basis for fundamentals and entry level firefighting competencies. Also used for reference are the Occupational Safety and Health Administration (OSHA) standards noted in 29 CFR 1910.132 This is a standard that directly relates to occupational competencies for safety and specifics safe practices for general industry. The fire service falls into this general industry category.

NFPA cites numerous recommendations for minimum standards when it comes to firefighter safety. What NFPA does not do in most instances is address how to be compliant with the recommended minimum standards. This often leads to fire departments interpreting what they believe a particular standard is saying, and then writing a policy for its personnel to meet this standard. The governing NFPA standard on safety for firefighters is NFPA 1500. This standard gives departments a global view of firefighter safety and then cites specific NFPA standards where necessary to fully explain each standard.

The NFPA establishes the industry standards that we as firefighters are essentially governed by albeit by recommended minimum standard. The NFPA 1500, 1001, and 1971 standards form the basis of my findings on recommended minimum standards to reduce what is the common safe practice in the fire service that prevent or reduce fire scene exposure. Most fire departments use NFPA as the basis for the development of their policy because these standards are widely accepted and specific to the fire service. To the point that by not following these recognized industry standards, departments are opening themselves up to potential liability.

The first standard on recommended common safe practice in the fire services that prevent or reduce fire scene exposure is the NFPA 1500 Standard on Fire Department Occupational Safety and Health Program 2007 Edition outlines general recommended practices related to Personal Protective Equipment.

> The fire department shall provide each member with protective clothing and protective equipment that is designed to provide protection from the hazards to which the member is likely to be exposed and is suitable for the tasks that the member is expected to perform (NFPA, 2007).

The standard continues to outline a recommendation to when the protective equipment shall be used. "Protective clothing and protective equipment shall be used whenever the member is exposed or potentially exposed to the hazards for which it is provided" (NFPA, 2007, p. 1500-16). The problem with this recommendation is that the potential dangers such as smoke and products of combustion that are toxic not visible. Due to this frequency of unseen danger the firefighter is or potentially is exposed to a hazard. In his

article “Tackling a lingering and hidden menace” (Fire International, April 2002 p. 23), Russel speaks to the hazardous profession and unseen dangers to today’s firefighters.

> Fire, smoke, inhalation, suffocation, backdrafts and unstable buildings all make the job one of the most dangerous and stressful in the world today. However, there are manifold unseen dangers that today’s firefighters need to be aware of. Many of these have not bee taken seriously in the past, with serious consequences for the victims - sometimes years after the incident. Such dangers come in many guises and can be more of a threat because, by their very nature, they are not necessarily visible to the crews who turn out to tackle the fire and the can also easily contaminate firefighter’s kits and spread from the fire scene to the tenders, the station and even in to the home (Russel, 2002).

This researcher has previously explained that firefighters only associate a hazard when it is seen. Chemicals with known carcinogens are not always seen, therefore giving the firefighter no clear threat to their being. During the incipient phase of a structure fire, the firefighter is acutely aware of the potential to radiant and thermal injury to them if not protected. Take the same fire which is now in a smoldering phase with little to no smoke or visible danger. That same firefighter will not have the same acuity to a threat, and therefore not wear a piece of personal protective equipment or their self contained breathing apparatus to protect them self. This was noted in (Brandt-Rauf, Fallon, Tarantini, Idema, and Andrews 1988) research on Health hazards of firefighters: exposure assessment.

> It should also be noted, however, that in several fires respiratory protection was used only partially or not al all (presumably owing to the impression of low

> smoke intensity); yet it was at these same fires that appreciable concentrations of hazardous materials (particularly carbon monoxide and benzene) were recorded and thus the firefighters were being directly exposed (Brandt-Rauf et al.1988).

The NFPA 1500 standard does a little better job in outlining when [emphasis added] the firefighter should use the respiratory protection of a self contained breathing apparatus under the respiratory protection program part of this standard.

> When engaged in any operation where they could encounter atmospheres that are immediately dangerous to life or health (IDLH) or potentially IDLH, or where the atmosphere is unknown, the fire department shall provide and require all members to use self contained breathing apparatus (SCBA) that has been certified as being compliant with the NFPA 1981, standard on Open Circuit Self-contained Breathing Apparatus for Fire and Emergency Services. (NFPA, 2007, p. 1500-20)

This is the only place this researcher can find in the NFPA 1500 standard where it specifically lists any operation and where the atmosphere may be unknown. This gives departments clear language on the when a firefighter should use and in what type of environment, a self contained breathing apparatus. This can easily be translated to a standard operating procedure or standard operating guideline for departments.

'Any operation' and 'unknown' are much more descriptive for use by departments in policy. Using the term 'likely' in the aforementioned paragraph on protective equipment, leaves to much room for speculation by the firefighter. It is a roll of the dice that the firefighter may be exposed to a known toxic chemical that causes cancer. Where by the language used in this standard is clearly left to speculation.

The second recommended common safe practice in the fire service that prevent or reduce fire scene exposure is the NFPA 1001 Standard on Basic Firefighter Qualifications . This standard outlines the basic requisite knowledge and skills an entry-level firefighter should be proficient in for firefighting. This standard lists under the general skill requirement "The ability to don personal protective clothing within one minute; doff personal protective clothing and prepare for reuse" (NFPA, 2007, p. 1001-8). Again the emphasis is on the equipment and how rapidly one can don the gear; not on when to don the gear. The NFPA association places the emphasis on donning the personal protective equipment in a one-minute time line. It is imperative that our firefighters dress quickly to respond to an emergency we cannot forget to educate them on the when to wear the equipment.

The next recommend safe practice is in the CCFD's selected textbook for firefighter entry-level training. This text is used at the entry level and throughout a firefighter's career outlining the required fundamental skills and knowledge. The manual has a dedicated chapter for safety. Following the NFPA 1001 standards the chapter on safety in the manual outlines skills and knowledge-based objectives. The include the level of protection, the importance of standards, limitations and maintenance of personal protective equipment, and the hazards of smoke and other toxic environments (2004).

The authors summarize the personal protective equipment as an essential component of a firefighter's safety system:

> PPE ensembles provide specific protections, so an understanding of their designs, applications, and limitations is critical. For example, a structural firefighting ensemble will protect the wearer from the heat, smoke, and toxic gases present in

> building fires. It cannot provide long-term protection from extreme weather conditions and limits range of motion. The more you know about the protection your PPE can provide, the better you will be able to judge conditions that exceed its limitations (Fundamentals of Firefighter Skills, 2004).

The same safety chapter goes on to outline the protection provided by personal protective equipment. Listed in the text is seven things that personal protective equipment protects the wearer from. These include thermal protection, repel water, provide impact protection, provide protection against cuts and abrasions furnishes padding against injury, increases your visibility, and provide respiratory protection (2004).

Notice no reference to the ensembles ability to protect the wearer from toxic substances. This is a primary design feature of all structural fire fighting gear. The NFPA 1971 standard on Protective Ensembles for Structural fire Fighting and Proximity Fire Fighting lists the performance requirements for each layer of protective material the comprise the structural firefighting gear. The outer shell, the vapor barrier, and the thermal liner are tested for flame resistance, liquid penetration and thermal protection. The vapor barrier specifically is designed to allow excess moisture from the wearer to evaporate while simultaneously resisting liquids or gases from contacting the skin of the wearer (NFPA, 2007).

The Fundamentals of Firefighter Skills chapter on safety and the protection of personal protective equipment simply notes that the outer layer of the structural firefighting garment “makes it easier to identify contaminants such as hydrocarbons, blood, and body fluids on the coat” (Fundamentals of Fire Fighter skills, 2004, pp. 33).

No further mention of the protection from toxic substances commonly found on the fire ground. Also, there is no requisite knowledge required for the basic firefighter coming into the fire service to educate him or her on the potential of carcinogens present in and around the fire scene. Also, there is no explanation of how, where, or when these toxins are present and how to avoid such contamination.

The next recommended safe practice is found in the 29 CFR 1910.132, subpart I-Personal Protective Equipment (a):

> This lists the employers obligation and application: Protective equipment, including personal protective equipment for eyes, face, head, and extremities, protective clothing (...) shall be provided, used, and maintained in a sanitary and reliable condition wherever it is necessary by reason of hazards of processes or environments, chemical hazards, radiological hazards, or mechanical irritants encountered in a manner capable of causing injury or impairment in the function of any part of the body through absorption, inhalation or physical contact (OSHA, 2005).

The code further delineates the required training that the employer is required to provide. “Each employee shall be trained to know at least the following: (i) when PPE is necessary; (ii) what PPE is necessary; (iii)How to properly don, doff, adjust, and wear PPE; (iv) The limitations of the PPE; and (v) The proper care, maintenance, useful life and disposal of PPE” (OSHA, 2005, pp. 193).

The studies noted in the literature review were conducted to review existing literature on toxic substances and known carcinogens established a foundation for this research. It is clear from this research that toxic substances and known carcinogens are

present during firefighting. There is strong evidence to support a correlation between specific types of cancer and the occupation of a firefighter.

While there is evidence to support this chemical presence, the research conducted thus far is limited to support a clear correlation between specific types of cancer and the firefighter. While some studies have clear correlation, the sample groups are small and the focus is narrow. Similar studies in this field will show clear evidence of carcinogens but they too have little statistical evidence to prove a high incidence or correlation to specific cancers. All agree however, that toxic chemicals and known carcinogens are present in and around firefighting and that firefighters are clearly at risk.

It is clear that the presence of national standards and recommendations exist but they are just that, recommendations. Literature review of common practices from a text book perspective and recognized standards also lacks sufficient education for the firefighter on the threat of exposure to known toxins and carcinogens.

The research reaffirms the lack of awareness, education and common safe practices in the fire service to reduce fire scene exposure of toxins and known carcinogens to our firefighters. The fire service clearly needs to become proactive with education of the on scene danger of toxic substances and known carcinogens to prevent cancer incidents and exposure to our firefighters.

Additionally, the fire service needs to take a more active role in the research of toxic substances and carcinogens related to the occupation of firefighters. Clearly there is overwhelming evidence to support a direct correlation between cancer and firefighting. Everyday fire service professionals are placed in harms way and exposed to these carcinogens. The research shows that numerous conclusions to the research on the subject

are prevalent. That is not to say that a concerted effort is going forth in this research, but it is limited in scope and focus or cohort groups are relatively small.

To further this point, the research in this literature review appears to have been gathered from numerous cancer research and registries from College Universities and hospitals to independent researchers. Statistically speaking, the numbers are too small and the research is limited to these focus groups, and not the fire service as a whole. This type of large occupational cohort study would need the assistance of the fire service and researchers alike to gather the necessary records and histories of firefighters to capture the data and make a definitive answer to whether firefighters are more at risk that the general population.

Finally, the research of common safe practices to reduce or mitigate fire scene exposure is lacking substance. As the research explains, there are general standards, regulations, recommendations and education on commons safe practices. It is evident that the fire service would need to further standardize both standards and regulations toward the goal of protecting the firefighter on the fire scene. It would seem logical that this start with the fire service and it's members who sit on the numerous committees in the NFPA. Occupational safety associations need to work closely with fire service professionals to establish the regulations and standards so that fire service instructors have standardized curriculum to teach the fire service personnel on safety related practices such as these.

Procedures

For this Applied Research Project, an evaluative research method was utilized in obtaining information for the purpose of developing an action plan and policy that encompasses prevention and mitigation of the known toxic substances and carcinogens to

firefighters. The descriptive research approach focused on performing research that evaluated current conditions affecting the safety of firefighters on the fire scene. We cannot reduce the cause or amount of these toxic substances and carcinogens, we can and should work toward preventing unnecessary exposure and mitigate the fire scene where we can and when we can toward this effort. The primary goal of this research is to evaluate the need for creating an action plan and policy toward prevention and mitigation of toxic substances and known carcinogens.

The specific criteria I propose to evaluate is found in the research questions. What toxic substances and carcinogens are present during firefighting? Is there a correlation between specific type of cancer and the occupation of a firefighter? What are the common safe practices? What action plan and policy would best serve to prevent and mitigate these toxic hazards for the firefighter?

The initial phase of this research project incorporated a review of available material pertinent to the project's topic. Examples of material considered included literature from periodicals, journal articles, textbooks, national standards, manuals and sources from the internet. Some of the key words used for internet research purposes included terms such as "cancer", "firefighter safety", "cancer in firefighters", "personal protective equipment and cancer" and related words. Research was initiated at the Resource Learning Center (LRC) while the researcher attended the Executive Development (ED) course at the National Fire Academy. Research continued via Internet upon returning home.

To address the problem that the CCFD has not developed an action plan and policy to prevent, mitigate these hazards, the first question posed was what toxic

substances and carcinogens are present during firefighting? The intent of this question was to determine what 'known' toxic substances and carcinogens are present when a firefighter fights a fire. Most all of the research found centered on a general term of "firefighting", the "fire scene" or structure fire. No real delineation was made for a residential fire, commercial fire, vehicle fire etc. This researcher uses the term 'fire scene' to encompass all fires where a known or potential (IDLH) is suspected.

The research clearly established that firefighters are exposed to recognized toxic substances and known or probable carcinogens. These include benzene, polycyclic aromatic hydrocarbons, benzo(a)pyrene, formaldehyde, chloropehenols, dioxins, ethylide oxide, orthortoluidine, polychlorinated biphenyls, vinyl chloride, methylene chloride, trichloroethylene, diesel fumes, arsnic and asbestos (Treitman et al, 1980). (Austin, Wang, Ecobichon and Dussault, 2001) further describe the volatile organic compounds found in smoke; These compounds are prevalent at every fire in varying amounts and in combination with other familiar compounds, such as hydrogen cyanide and carbon monoxide (Austin et al 2001). Therefore it is established that toxic substances and known carcinogens are present during firefighting.

The second project question posed is there a correlation between specific type of cancer and the occupation of a firefighter? The intent of this question was to establish a correlation between known toxic substances and known carcinogens and the fire fighter occupation. A correlation between carcinogens and firefighting is established. The research dated back to the 1940-50's to within a few years of present time. Researchers agree that there is a direct correlation that proved evidence of known carcinogens. However, researchers did not agree on specific types of cancer and firefighters

conclusively. During the past several decades relationships between cancer and firefighters have been conducted:

> [Brownson et. al. 1987, Vena and Fiedler 1987, Heyer et.al. 1990, Sama et. al. 1990, Demers et. al. 1992, Guidotti 1993, Aronson et. al. 1994, Burnett et. al. 1994, Tornling et. al. 1994, Guidotti 1995, Baris et.al. 2001] suggested that leukemia, non-Hodgkins's lymphoma, multiple myeloma, brain and bladder cancer have strong evidence, and rectal, colon, stomach, prostate cancer, and melanoma have a weaker but plausible evidence of association with firefighting (Kang et.al., 2008).

Limitations of this research exist in the inconsistencies with a number of studies; namely the strength of the evidence reported by other authors. Furthermore, researchers reviewed all cancers combined, lung cancer and brain cancer, and reported that only the standardized mortality ratio of bran cancer was consistently higher in firefighters (Hass, Gochfeld, Robson, and Wartenberg 2003).

Other studies show association of firefighting and other types of cancer including laryngeal (Muscat and Wynder 1995), lip, nasopharynx, pancreas, soft tissue sarcoma and Hodgkin's disease (Ma, Lee, Dleming, and Dosemeci 1998), testicular (Bates, Fawcett, Garrett, Arnold, Pearce, and Woodward 2001); Stang, Jockel, Baumgardt-Elms, and Ahrens 2003), male breast cancer, and thyroid cancer (Ma, fleming, Lee, Trapido, Gerace, Lai, H., and Lai, S. 2005), (Kang et. al. 2008). Due to all of the inconsistencies in the aforementioned research, there continues to be a need for additional studies on the relationships between these carcinogens and firefighter occupation.

The third question posed is what are the common safe practices in the fire service that prevent or reduce fire scene exposure. The intent of this third question was to establish what common safe practices exist in the fire service to prevent or reduce how firefighters are exposed on the fire scene. Research focused on standards in the fire service versus individual practices in cohort group of fire departments.

The individual practices of random departments would likely be loosely or specifically based off of standards known in the fire service. The researcher wanted to establish the standards widely used by the fire service. These specific reference standards were, NFPA, OSHA, and the CCFD manual of text on entry level firefighting used in academy.

NFPA outlines recommended practices for health and safety in the standard on Fire Department Occupational Safety and Health Program known as NFPA 1500. Further recommendations were noted in the standard on Protective Ensembles for Structural Fire Fighting and Proximity Fire Fighting known as 1971. It has been established in this research that there are recommended safe practices relative to general conditions in which the firefighter should wear their assigned PPE. What NFPA fails to do is tell you any specific conditions that the PPE should be worn. When PPE should be worn is equally if not more important that general conditions such as; exposed or potentially exposed to hazards. Toxic substances or carcinogens that can harm or fatally injury the employee are not mentioned.

NFPA does a better job in detailing when a firefighter should wear the SCBA. NFPA recommends that firefighters wear the SCBA during any operation that is IDLH or suspected or unknown. This gives departments some more definitive times when the

SCBA should be worn. OSHA from a federal or governmental stand point simply requires the department to provide PPE, but OSHA does expand on the fact that employers have to teach employees the limitations, dangers, when to wear and what kind of PPE to wear.

The manual used by CCFD is standard based text manual of reference for the essential firefighting tasks a new member in the fire service should be proficient when learning how to be a firefighter. This manual also outlines general safe fire ground. However, the manual is based off of the NFPA standard of recommendations; with a focus on words such as ‘should’ and not ‘when’ a firefighter should protect him or her.

Results

The following result from the first question: What toxic substances and carcinogens are present during firefighting? The research demonstrated clearly that the firefighter is exposed to a number of organic compounds, air contaminants and carcinogens. All of which have either acute or chronic health related problems.

The National Research Council’s committee on Fire Toxicology bests explains the present day issue of exposure to carcinogens in fire smoke:

> A complex mixture of toxic gases, fumes, and particulates is produced when buildings and their contents burn. Although the combustion of traditional building materials may produce toxic substances, firefighters probably are exposed to a greater variety now than in past due to the increasing introduction of plastics and other synthetic compounds into building materials and furnishings. The most commonly observed carcinogens in fire smoke are benzene and polycyclic aromatic hydrocarbons, such as benzo[a]pyrene (Brandt-Rauf et al. 1988).

These toxic substances and carcinogens are among a host of compounds that were found in numerous studies related to the presence of toxic substances and carcinogens. The research has shown that these high concentrations of contaminants are present during firefighting.

The next question in the research project was to determine if there is a correlation between specific types of cancer and the occupation of a firefighter? Researcher's have varying opinion as to the correlation to specific types of cancer and the relationship to the occupation of a firefighter. To make this determination a large cohort study that a large occupational cohort study followed by a 'nested case-control' study with several cancer endpoints is needed. Records, questionnaires, histories and reconstruction of firefighting exposure histories are ideas of Dr. Bates; to truly capture the correlative history to make definitive answer to whether firefighters by occupation are at a greater risk (Bates, 2007).

The NRS in Nevada has listed in legislation reasonable association with specific types of cancer and the occupation of a firefighter. These correlations are consistent with the additional research listed in the literature review. The following cause and cancers associated with the firefighter are listed:

(a) Diesel exhaust, formaldehyde and polycyclic aromatic hydrocarbon shall be deemed to be known carcinogens that are reasonably associated with bladder cancer.

(b) Acrylonitrile, formaldehyde and vinyl chloride shall be deemed to be known carcinogens that are reasonably associated with brain cancer.

(c) Diesel exhaust and formaldehyde shall be deemed to be known carcinogens that are reasonably associated with colon cancer.

(d) Formaldehyde shall be deemed to be a known carcinogen that is reasonably associated with Hodgkin's lymphoma.

(e) Formaldehyde and polycyclic aromatic hydrocarbon shall be deemed to be known carcinogens that are reasonably associated with kidney cancer.

(f) Chloroform, soot and vinyl chloride shall be deemed to be known carcinogens that are reasonably associated with liver cancer.

(g) Acrylonitrile, benzene, formaldehyde, polycyclic aromatic hydrocarbon, soot and vinyl chloride shall be deemed to be known carcinogens that are reasonably associated with lymphatic or haemotopoietic cancer.

(h) Diesel exhaust, soot, aldehydes and polycyclic aromatic hydrocarbon shall be deemed to be known carcinogens that are reasonably associated with basal cell carcinoma, squamous cell carcinoma and malignant melanoma.

(i) Acrylonitrile, benzene and formaldehyde shall be deemed to be known carcinogens that are reasonably associated with prostate cancer.

(j) Diesel exhaust, soot and polychlorinated biphenyls shall be deemed to be known carcinogens that are reasonably associated with testicular cancer.

(k) Diesel exhaust, benzene and X-ray radiation shall be deemed to be known carcinogens that are reasonably associated with thyroid cancer (NRS, 2009).

What are the common safe practices in the fire service that prevent or reduce fire scene exposure? Research determined that the fire service has outlined some common safe practices. This research looked at the NFPA 1500, 1971, OSHA standards and the text book Fundamentals of Firefighting Skills. These references agree that departments

are responsible for providing PPE as a safe practice. This includes the SCBA as a means for safe practice on the fire ground.

NFPA 1500 Standard on Fire Department Occupational Safety and Health Program 2007 Edition outlines general recommended practices related to Personal Protective Equipment:

> The fire department shall provide each member with protective clothing and protective equipment that is designed to provide protection from the hazards to which the member is likely to be exposed and is suitable for the tasks that the member is expected to perform (NFPA, 2007).

NFPA 1500 only clearly states when the SCBA should be worn. When the firefighter is working in an IDLH or potentially IDLH and when the atmosphere is unknown (NFPA, 2007). The manual of Firefighting Skills summarizes the common safe practice for the firefighter in the following way:

> PPE ensembles provide specific protections, so an understanding of their designs, applications, and limitations is critical. For example, a structural firefighting ensemble will protect the wearer from the heat, smoke, and toxic gases present in building fires. It cannot provide long-term protection from extreme weather conditions and limits range of motion. The more you know about the protection your PPE can provide, the better you will be able to judge conditions that exceed its limitations (Fundamentals of Firefighter Skills, 2004).

However, the manual only lists one other reference to the presence of toxic substances when it simply notes that the outer layer of the structural firefighting garment

“makes it easier to identify contaminants such as hydrocarbons, blood, and body fluids on the coat (Fundamentals of Fire Fighter skills, 2004).

Final conclusions of the research reveal that toxic substances definitely exist on the fire ground. Furthermore, these proliferation and variance of these substances is far more than this researcher ever expected. Based on the research, the fire service needs to do more to educate firefighters about the presence of these toxic substances and carcinogens.

There is a strong correlation of specific toxic substances and carcinogens and the occupation of the firefighter. Research shows that all studies agree on correlation but vary on the specific types of cancer and the occupation of the firefighter. Nonetheless, specific cancers are known and associated with specific exposure to organic substances that firefighters come in contact with daily. Acknowledging the existence of these correlations is the first step of preventing exposure from them.

Finally, the research shows that there are some common safe practices outlined in the research on how a firefighter is to protect them from fire ground exposure. However, it is non-specific with the exception of the NFPA 1500 standard relating to when the firefighter should wear the SCBA. More emphasis is placed on the employer providing it and that the firefighter should use it when a hazard is likely and the PPE is suitable. Leaving the use of the PPE up to the discretion of the firefighter.

Discussion

Though toxic substances and known carcinogens exist and a correlation to specific carcinogens to the firefighter occupation are known; firefighters are not educated on how to protect themselves. The fire service is following national standards and

recommendations on what to provide the firefighter to provide protection. Yet, despite the evidence of these toxic substances and carcinogens the fire service does very little to thoroughly educate the fire fighter on the presence of these substances and the consequence of exposure, if the safety precautions are not taken.

This researcher believes that firefighters are better trained at an operational level of hazardous materials response on the dangers of such incidents; versus the everyday occurrence of the vehicle, trash, or structure fire. These fires are hazardous materials incidents yet they are treated as routine fires and the level of awareness for safety pales in comparison to the 'known' hazardous materials incident. The fire service simply does not treat them with the same equality for safety.

Twenty four states currently have presumptive cancer laws in full effect with eight more pending as of April 2009 (TriData, 2009). States appear to recognize this occupational threat to firefighters by enacting legislative law to protect the firefighter. The fire service needs to due a far better job at recognizing this same threat to our firefighters and begin to educate them on these present dangers.

Additionally, the fire service needs to become far more involved in the research of these toxic substances and carcinogens. One primary way that the fire service can become more involved is in capturing specific career history. Firefighters need to be tracked from the time they enter the fire service up to and including death. Essentially the life of the firefighter needs to be monitored by calls responded to, exposures, cancer screening, and continued through retirement.

If cancer is found it is reasonable that it occurred through their occupation to a great degree, thus the presumptive cancer laws. Additionally, the extended length of

monitoring the firefighter or retired firefighter is the latency of cancer. Cancer is often found after twenty years or more. By establishing a process whereby the firefighter is tracked throughout their career and retirement; researchers can better find correlation of what toxins and cancers exist as known threat to the firefighter.

It seems to this researcher that viable research has been conducted. However, due to relatively small cohort studies do not provide enough statistical evidence for researchers to produce definitive results. The researchers have evidence of the presence of toxins and cancers, but lack evidence in the correlation. It is correlation between cancer and the occupation of the firefighter that will allow researchers to show that firefighters are indeed at a higher risk for specific cancer versus the population norms currently established.

The scientific research is out there and clearly establishes the presence of toxins and carcinogens. Although researchers disagree on specific types of cancers and correlation of these cancers to the occupation of a firefighter; a renewed commitment to safety by firefighters is critical. Simple solutions do exist for complex situations. Firefighters must commit to wearing proper protective clothing, decontaminate their turnout gear immediately after use, and training. Training specifically aimed at the toxins and carcinogens that are a real threat to their career and to their life.

Recommendations

Results show that numerous and prolific toxic substances and carcinogens are present during firefighting. If the CCFD is to establish an action plan using and policy to prevent and mitigate these fire scene hazards this researcher recommends the following:

1. Educate all personnel on the presence of toxic substances and known or suspected carcinogens. This education must be established from the top down as well as the bottom up. An action plan and policy needs to be established and clearly demonstrated from the top down. Education must begin during academy instruction of recruit firefighters and must include all uniform personnel. Making personnel aware through education of the presence of toxic substances and carcinogens will be to prepare the CCFD personnel on the dangers of the job and goal of prevention of exposure will make an impact on protecting CCFD personnel.
2. Hold firefighters, officers, and chief officers accountable for implementation and compliance of this policy. There is really no margin of error with this policy. Strict adherence to such a policy must be established. This includes full use of PPE and the SCBA in all phases of a fire fight, decontamination procedures for immediate use after a fire, and training on the hazardous environment that a firefighter works. If a firefighter violates a policy than progressive discipline should result, in order to change the behavior. This is not limited to the line firefighter. Officers and chief officers bear a greater responsibility of enforcement and should be held accountable as well for their action or in-action toward this policy.

While we cannot reduce the cause or amount of these toxic substances and carcinogens, we can and should work toward preventing unnecessary exposure and mitigate the fire scene where we can and when we can toward this effort. By putting these recommendations into an action plan and policy, the CCFD will begin to make a positive change toward changing the paradigm its personnel toward this ever present danger.

Research further establishes the correlation of toxic substances and carcinogens with strong evidence linking specific types of cancers and the occupation of a firefighter. Researchers clearly have some varying opinion on specific correlation of type of cancers and the occupation of the firefighter. Yet, all agree that the firefighter is exposed to known carcinogens and the probability of such specific cancers do exist. Toward this effort of prevention and mitigation I offer the following.

1. Continuing education building on the previous recommendation. The focus should be on the basic etiology of cancer. In addition, what type of cancers firefighters are exposed to and how to prevent and mitigate exposure. Firefighters need to be fully aware of the types of cancer(s) that this occupation brings. The better educated firefighters are on the types of cancer and how they are exposed during the course of their normal duties; will better prepare them for and make them aware of the need to protect themselves. Recognition of unseen dangers, specifically toxic substances such as compounds and the cancer they are exposed to in relationship to their job is crucial.
2. Establish a way to capture the work history of the firefighter and exposures. Every exposure encountered by a firefighter should be recorded. I am not suggesting that every exposure be filed with a worker's compensation claim, but it should be reasonably recorded that an exposure occurred. Filing a compensation claim on every claim would likely weaken a case for a 'true exposure' should one occur. However, departments should establish and define what a 'true exposure' is and educate its personnel. Furthermore, what the firefighter should due should 'true exposure' occur. A similar process is conducted with blood borne pathogen exposure in most departments.

3. Continued research is needed on a collaborative effort of research between cancer registries, researchers, and the fire service. Specifically the International Association of Firefighters (IAFF) and the International Association of Fire Chief's (IAFC) need to spear head this effort. Both of these large Associations have the means and resources to forward such a cause. This will line up with goals of both associations toward the Health and Safety efforts they already have established.

Creating a policy in and of itself will not produce change. This recommendation also hinges on education. Knowledge is power. When coupled with a positive change and capturing historical data on every firefighter relative to exposure; the CCFD will greatly increase the safety and health of it's firefighters. However, CCFD as well as other fire departments need the support of it's associations toward this effort. By taking a more participative and active role, both the IAFF and IAFC can assist researchers in finding to proven data to support the correlation of carcinogens. After which, they can lead the fire service establishing standards and recommendations in establishing common safe practices that truly protect firefighters.

Additionally, the fire service currently establishes very little in safe practices to reduce fire scene exposure. We must reduce the risk to firefighters by educating and training firefighters on the prevention and mitigation these toxins and known carcinogens. Based on the research the author concluded that an action plan and policy to prevent, mitigate and reduce the firefighter exposure to the presence of cancer causing toxins should be done through policy, education, constant reinforcement and accountability of it's officers and firefighters.

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